**Survey of coral and fish assemblages on Pulley Ridge, SW Florida**

A report to the Gulf of Mexico Fishery Management Council

June, 2008

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Abstract

The coral reef community covering Pulley Ridge is the deepest known light-dependent coral reef on the US continental shelf. Located off the southwest coast of Florida, the ridge is a drowned barrier island colonized by several species of hermatypic coral and a fish community comprised of both deep and shallow water species. Pulley Ridge has been designated a habitat area of particular concern (HAPC) due to the presence of these coral formations. The Gulf of Mexico Fishery Management Council (GMFMC) has expressed concerns over ongoing damage to the habitat by fishing operations and is considering additional protective measures. The primary goals of this project were to determine the extent of scleractinian corals, especially *Agaricia* spp. as it is the most abundant hermatypic coral on the ridge, and examine fish diversity on the Pulley Ridge formation. The principle gear used to examine habitat and the fish community was a remotely operated vehicle (ROV), while the secondary gear used was a stationary camera array. Cruises in August 2007 and April 2008 resulted in 19 ROV dives and 12 camera array drops. There was a distinct difference in habitat between northern and southern Pulley Ridge, which resulted in distinct fish community compositions between the areas as well. Habitat to the north of the HAPC was characterized as one of three habitats: sand, pavement, and low relief outcrops, the latter two displaying varying degrees of live bottom coverage including several species of sessile and encrusting invertebrates and algae. The habitat in the southern area of Pulley Ridge was characterized as rock rubble with varying coverage of algae, coralline algae, hermatypic corals, solitary and encrusting sponges, octocorals, and antipatharians. Fish diversity was highest in southern Pulley Ridge on the rock rubble habitat. Sand tilefish (*Malacanthus plumieri*) mounds and red grouper (*Epinephelus morio*) pits were common in southern Pulley Ridge. *Agaricia* spp. was only observed in the southern portion of Pulley Ridge both inside and outside the HAPC in depths between 61.3 and 89.0 m. Results from this study will be valuable to the GMFMC in making future effective management decisions.

## Introduction

The deepest known hermatypic coral reef in the continental U.S. is located on Pulley Ridge off the southwest coast of Florida (Hine *et al.*, 2008). The ridge itself is a drowned barrier island approximately 100+ km long by 5 km wide northwest of the Dry Tortugas and running parallel to the Florida peninsula. The shallowest areas on the ridge are about 60m deep. Surprisingly, at this depth, large areas with up to 60% live coral coverage have been located in the southern portion of Pulley Ridge (Halley *et al*., 2003) even though only 1-2% of surface light is available to the reef community (Jarrett *et al*., 2005). The coral *Agaricia* sp. (Figure 1) is one of the most abundant hermatypic corals in southern Pulley Ridge. This coral forms plates up to 50 cm in diameter and are adapted to low light environments. In excess of 60 fish species have been reported, comprised of a mixture of shallow and deep water species (Halley *et al*., 2003).

Pulley Ridge is one of the last hermatypic scleractinian coral reefs in the U.S. to receive protection from targeted fishing activity, specifically bottom longlines. It was designated a Habitat Area of Particular Concern (HAPC) in 2005 by the Gulf of Mexico Fishery Management Council (GMFMC) and some fishing activities have been restricted, but growing concern for corals in the area may lead to additional management actions. .

The goals of this project were to determine the extent and magnitude of scleractinian corals and other adjacent habitats and examine fish diversity on the Pulley Ridge formation. Data on the abundance and distribution of flora and fauna on the ridge will be needed to make effective management decisions. Of greater scientific value will be acquisition of data on shallow water species living in these depths, interactions between deep and shallow species in this unique ecosystem as well as searches for evidence of coral bleaching or other deleterious effects of climate change described in shallower ecosystems inhabited by similar species. This report is National Marine Fisheries Service Panama City Laboratory Contribution Number 08-10 .

Figure 1. *Agaricia* sp.coral observed in April 2008.

## Methods

Multibeam bathymetry and acoustic backscatter maps have been produced for approximately 60% of the Pulley Ridge HAPC. These maps were used for site selection and to guide the ROV during dives. Suspected hardbottom and reef sites were the primary targets. Surveys of Pulley Ridge were conducted in August 2007 and April 2008.

The principle gear used to characterize habitat and fish assemblages was a remotely operated vehicle (ROV) owned by the National Undersea Research Center (NURC) at the University of North Carolina at Wilmington (UNCW) and operated by them in April 2008 and by the NURC at the University of Connecticut (UConn) in August 2007. High currents required the use of a downweight to keep the ROV umbilical cable near the bottom throughout the dives. This downweight was tethered to the ROV umbilical and the ROV operated on a 30 m leash which provided sufficient freedom of movement to investigate habitat features within visual range of the transect line. The downweight configuration allowed the ROV to drift just above the bottom at a controlled over-the-ground speed of approximately 1.34 km/hr (range 0.93 to 2.8 km/hr). The geographic position of the ROV (± 3 m) was constantly recorded throughout each dive with a tracking system linked to the ship's GPS system. The ROV was equipped with lights and a forward-looking color digital video camera which provided continuous imaging data. These dives resulted in approximately 26 hours of underwater video documentation. The video footage was used to quantify *Agaricia* abundance as well as fish diversity. A fish species list was accumulated for each dive and the time, size, and depth of each observed plate of *Agaricia* coral was noted.

We also used a stationary video camera array to determine relative abundance of fish and percent cover of habitat in August 2007. The array was comprised of four Sony VX-2000 digital camcorders in Gates Diego underwater housings mounted at 90º angles to each other in the horizontal plane at a height of 30 cm above the bottom of the array. The camera array was allowed to soak on the bottom for at least thirty minutes during each deployment. This allowed sufficient time for sediment stirred up during camera deployment to dissipate and ensured tapes with an unoccluded view of at least twenty minutes duration. All fish captured on videotape were identified to the lowest discernable taxonomic level. Abundance values were calculated from the maximum number of fish of a given species in the field of view at any time during the twenty minute videotape. This is a more conservative abundance estimate than one derived from the total number of individuals observed, but it avoids multiple counts of the same individual and produces more reproducible estimates. The maximum number of each species as well as the percent coverage of each habitat type was determined.

A similar project examining shelf edge MPAs in the Gulf of Mexico has revealed modified fish behavior in the presence of ROVs. The lights, sounds, and motion of the vehicle attract some species and scare others whereas the stationary array has minimal impact upon fish behavior. However the array provides data on only a single spot with each deployment whereas the ROV can cover more than a kilometer with each dive. We have used both types of gear in an effort to maximize the area surveyed (ROV) and minimize fish behavior modification (array).

## Results and Conclusions

A total of 19 ROV dives were made along the ridge (Figure 2). Eight dives were made north of the HAPC (1 in April 2008 and the remaining of them in August 2007), 8 dives were made inside the HAPC in April 2008, and 3 dives were made to the west of the HAPC in April 2008. A distinct difference in habitat types existed between the northern and southern portions of the HAPC. The northern HAPC was characterized by three major habitats: 1) soft substrate/sand (hereafter denoted as SA), 2) pavement (PAV), and 3) low relief outcrops (LRO). SA habitats exhibited no relief and were composed of fine to coarse sand, sometimes mixed with shell hash. PAV habitats were composed of hardbottom with no relief, some degree of coverage with sessile and encrusting invertebrates and algae, and a presence of cracks/crevices up to 2 m deep. LRO consisted of rock outcrops with < 1 m relief, also with some degree of coverage of sessile and encrusting invertebrates and algae. The dominant benthic biota in terms of species richness and density were Porifera (70 taxa), Cnidaria (23 taxa), and algae (14 Rhodophyta, 8 Phaeophyta, and 9 Chlorophyta). The northern portion of the ridge primarily supports a heterotrophic octocoral-dominated community which lacks the reefal accumulation that is characteristic to the south. Habitats within the southern HAPC were consistently similar, but drastically different from the northern HAPC. The southern area was characterized as having anywhere from 70-100% rock rubble covered in varying degrees with live bottom providing some vertical relief for fish. Coral species observed included *Agaricia undata*, *Agaricia lamarcki*, *Montastraea cavernosa*, and *Leptoseris cucullata*. Various species of coralline algae were common as were the fleshy green alga *Anadyomene menziesii*, *Halimeda* sp., and the red alga *Kallymenia* sp. Other live bottom included solitary and encrusting sponges, octocorals, and antipatharians. Sand tilefish (*Malacanthus plumieri*) mounds (Figure 3) were common, approximately 1 m high and 1 m wide, and made entirely out of rock rubble. On several occasions, we observed sand tilefish hovering near their mound and then diving inside it as the ROV approached, utilizing a hole excavated on one side of the mound. Small reef fish such as chalk bass (*Serranus torugarum*), several species of damselfish (*Chromis* spp.), orangeback bass (*Serranus annularis*), and cherubfish (*Centropyge argi*) often aggregated on the mounds. Large pits, created and utilized by red grouper (*Epinephelus morio*) were also quite common in the southern HAPC. The majority of these pits were up to 2 m wide and 1 m deep, but a few were larger, approximately 3-4 m wide and 1-2 m deep. Often, exposed hardbottom in the form of rock outcrops were visible in the bottom of the pits. Fish were usually abundant inside the pit because of the habitat complexity and often a single red grouper was present.

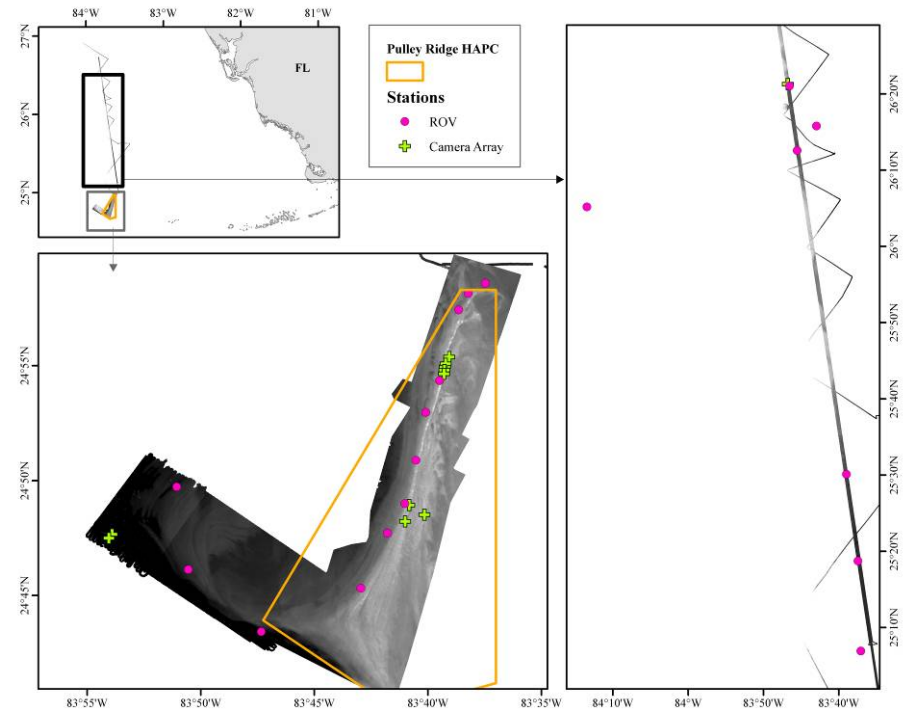

Figure 2. ROV and camera array stations along Pulley Ridge.


Figure 3. Sand tilefish *(Malacanthus plumieri*) mound.

As a result of differing habitats, fish assemblages were also dissimilar between the northern and southern portions of the HAPC. A list of all fish species present in each habitat type can be found in Table 1. Rock rubble habitat in the southern HAPC had the highest fish diversity with 44 different species. Low relief outcrops had 29 species, followed by pavement with 17 species, and finally 12 different fish species in sand habitat. The majority of ROV dives started on the west side of the ridge and worked southeast over the structure. Small reef fish densities were higher on top of the ridge; however grouper and snapper were not abundant anywhere along it. Because of the pits in the southern HAPC, red grouper was the most abundant grouper species in that area, however, scamp (*Mycteroperca phenax*) was the most frequently observed grouper in the northern HAPC.

Table 1. Fish species observed on Pulley Ridge by habitat. Northern Pulley Ridge was made up of SA= sand, PAV=pavement, LRO=low relief outcrops. Southern Pulley Ridge was made up of RR=rock rubble. X denotes presence of a fish species in a particular habitat.

| Taxa | Common Name | SA | PAV | LRO | RR |
|---|---|---|---|---|---|
| Muraenidae | | | | | |
| Undetermined | undetermined moray eel | X | | | |
| Synodontidae | | | | | |
| *Synodus intermedius* | sand diver | X | | X | |
| Ogcocephalidae | | | | | |
| *Ogcocephalus* sp. | undetermined batfish | | X | | |
| Holocentridae | | | | | |
| *Holocentrus rufus* | longspine squirrelfish | | | | X |
| *Holocentrus* spp. | undetermined squirrelfish | | | X | X |
| Scorpaenidae | | | | | |
| Undetermined | undetermined scorpionfish | | X | | |
| Serranidae | | | | | |
| Anthiinae | anthiids | | | X | X |
| *Centropristis ocyurus* | bank sea bass | | X | X | |
| *Diplectrum formosum* | sand perch | | X | | |
| *Epinephelus cruentatus* | graysby | | | | X |
| *Epinephelus drummondhayi* | speckled hind | | | X | |
| *Epinephelus morio* | red grouper | | | X | X |
| *Epinephelus* sp. | undetermined grouper | | | | X |
| *Liopropoma eukrines* | wrasse bass | | X | X | X |
| *Mycteroperca bonaci* | black grouper | | | | X |
| *Mycteroperca microlepis* | gag | | | X | |
| *Mycteroperca phenax* | scamp | | | X | X |
| *Paranthias furcifer* | creole-fish | | | X | |
| *Pronotogrammus martinicensis* | roughtongue bass | | | X | X |
| *Schultzea beta* | school bass | | | | X |
| *Serranus annularis* | orangeback bass | | X | X | X |
| *Serranus notospilus* | saddle bass | X | X | | X |
| *Serranus phoebe* | tattler | X | X | X | X |
| *Serranus tortugarum* | chalk bass | | | | X |
| Priacanthidae | | | | | |
| *Priacanthus arenatus* | bigeye | | | X | X |
| *Priacanthus cruentatus* | glasseye snapper | | | | X |
| *Pristigenys alta* | short bigeye | | X | X | X |
| Apogonidae | | | | | |
| *Apogon affinis* | bigtooth cardinalfish | | | | X |
| *Apogon pseudomaculatus* | twospot cardinalfish | | | | X |
| *Apogon* spp. | undetermined cardinalfish | | | X | X |
| Malacanthidae | | | | | |
| *Malacanthus plumieri* | sand tilefish | | | | X |
| Carangidae | | | | | |
| *Seriola dumerili* | greater amberjack | | | | X |
| *Seriola* spp. | undetermined amberjack | | | X | |

| Taxa | Common Name | SA | PAV | LRO | RR |
|---|---|---|---|---|---|
| Lutjanidae | | | | | |
| *Lutjanus mahogoni* | mahogany snapper | | | | X |
| *Lutjanus* sp. | undetermined snapper | | | | X |
| *Rhomboplites aurorubens* | vermilion snapper | | | X | |
| Haemulidae | | | | | |
| *Haemulon album* | margate | | | | X |
| *Haemulon melanurum* | cottonwick | | | X | |
| *Haemulon striatum* | striped grunt | | | | X |
| Sparidae | | | | | |
| *Pagrus pagrus* | red porgy | X | X | X | X |
| Undetermined | undetermined porgy | | | X | X |
| Sciaenidae | | | | | |
| *Equetus lanceolatus* | jack-knife fish | | X | X | X |
| *Equetus umbrosus* | cubbyu | | | X | X |
| Chaetodontidae | | | | | |
| *Chaetodon aya* | bank butterflyfish | | | X | X |
| *Chaetodon ocellatus* | spotfin butterflyfish | | X | X | X |
| *Chaetodon sedentarius* | reef butterflyfish | | X | X | X |
| Pomacanthidae | | | | | |
| *Centropyge argi* | cherubfish | | | | X |
| *Holacanthus bermudensis* | blue angelfish | | | X | X |
| *Holacanthus tricolor* | rock beauty | | | | X |
| *Pomacanthus arcuatus* | gray angelfish | | | | X |
| *Pomacentrus partitus* | bicolor damselfish | | | | X |
| Pomacanthidae | | | | | |
| *Chromis enchrysurus* | yellowtail reeffish | X | X | X | X |
| *Chromis insolatus* | sunshinefish | | | | X |
| *Chromis scotti* | purple reeffish | | | | X |
| *Chromis* spp. | undetermined damselfish | | | X | |
| Labridae | | | | | |
| *Bodianus pulchellus* | spotfin hogfish | | | X | X |
| *Decodon puellaris* | red hogfish | | | | X |
| *Halichoeres bathyphilus* | greenband wrasse | | | | X |
| *Halichoeres bivittatus* | slippery dick | | | | X |
| *Halichoeres garnoti* | yellowhead wrasse | | | | X |
| *Halichoeres* spp. | undetermined wrasse | X | X | X | X |
| *Hemipteronotus* spp. | undetermined razorfish | X | | | |
| Scaridae | | | | | |
| *Sparisoma atomarium* | greenbloth parrotfish | | | | X |
| Gobiidae | | | | | |
| Undetermined | undetermined goby | X | | | |
| Sphyraenidae | | | | | |
| *Sphyraena barracuda* | barracuda | | | | X |
| Opistognathidae | | | | | |
| *Opistognathus aurifrons* | yellowhead jawfish | | | | X |
| Bothidae | | | | | |
| *Syacium micrurum* | dusky flounder | | | | X |
| Undetermined | undetermined flounder | X | X | | |

| Taxa | Common Name | SA | PAV | LRO | RR |
|---|---|---|---|---|---|
| Balistidae | | | | | |
| *Monacanthus* spp. | undetermined filefish | | X | | |
| *Balistes* spp. | undetermined triggerfish | | | | X |
| *Balistes vetula* | queen triggerfish | | | | X |
| Ostraciidae | | | | | |
| *Lactophrys polygonia* | honeycomb cowfish | | | | X |
| *Lactophrys quadricornis* | scrawled cowfish | X | | | |
| Tetraedontidae | | | | | |
| *Canthigaster rostrata* | sharpnose puffer | | | X | X |
| Diodontidae | | | | | |
| *Chilomycterus* spp. | undetermined puffer | X | | | |
| *Diodon hystrix* | porcupinefish | | | | X |
| Undetermined | spiny puffer | | | | X |

Pulley Ridge contains the deepest known hermatypic coral reef in the U.S. The most common scleractinian corals are species of *Agaricia*. We observed *Agaricia* spp. only in the southern portion of Pulley Ridge both inside and outside the HAPC in depths between 61.3 and 89.0 m (Figure 4). With the exception of two dives, we observed less than 20 individual plates of coral per dive ranging in diameter between 5 and 30 cm. The other two dives had higher densities of *Agaricia* spp. One had 107 observations of coral while the other had 33 with plates ranging in diameter between 10 and 90 cm, the larger of these being clusters of overlapped plates, making it difficult to measure the diameter of the individual corals. One interesting observation was the abundance of dead *Agaricia*. It was common to see plates of coral which contained significant areas of dead tissue, however no stressed or bleached corals were seen. Corals appeared to be either healthy or dead (Figure 5).

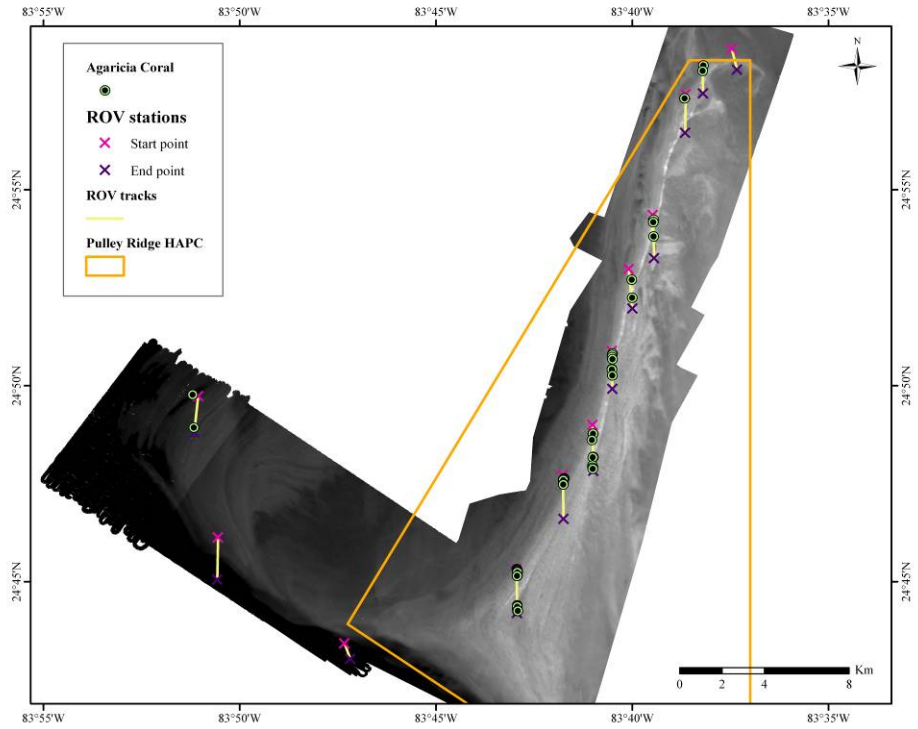

Figure 4. *Agaricia* observations along Pulley Ridge dive tracks.

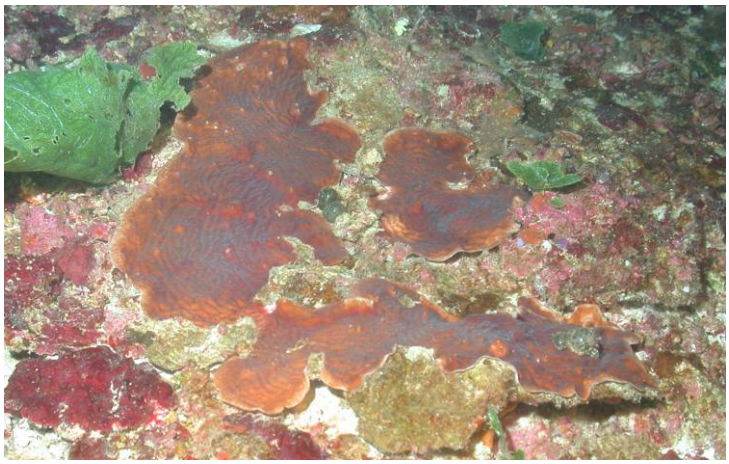
Figure 5. Live and dead *Agaricia* coral.

One dive in 2007 was in a sinkhole to the west of the ridge, 204 km north of the Dry Tortugas and 241 km west of Naples, Florida (Figure 2). The rim of the sinkhole was at 176 m deep and the deepest we went inside the sinkhole was ~206 m, although a maximum depth of 230 m has been observed (Reed *et al*., 2005). The rim of the sinkhole consisted of rock outcrops $\leq$ 1 m high and silty sand. The sinkhole itself had steep rocky walls with numerous overhangs. Most of the fish were found along the rim of the sinkhole. The most abundant of the fish species were snowy grouper (*Epinephelus niveatus*), queen snapper (*Etelis oculatus*), roughtongue bass (*Pronotogrammus martinicensis*), bigeye soldierfish (*Ostichthys trachypoma*), and slimeheads (Trachichthyidae).

Twelve camera array drops were made along the ridge; 1 north of the HAPC, 8 inside the HAPC, and 3 to the west of the HAPC. Habitat north of the HAPC consisted of 50% sand and 50% rock outcrops, 0.3 – 0.6 m relief and covered with attached epifauna (depth 79 m). The most abundant fish observed in this area were wrasses (*Halichoeres* sp.) and scamp (Figure 6). Camera array drops done inside the HAPC were all done on top of the ridge (depth 58 – 63 m), so no relief was noticeable on the videotapes, but habitat was 100% rock along with 30-50% coverage of the green alga, *Caulerpa* sp. The fish assemblage was dominated by chalk bass (Figure 7). Drops made to the west of the HAPC were done in deeper waters, 104 – 117 m. Again, they were done on top of the ridge, so no relief showed on the videotapes, but the habitat was 100% rock, however no *Caulerpa* was found at these depths. The most abundant fish here were roughtongue bass, creole-fish (*Paranthias furcifer*), and red snapper (*Lutjanus campechanus*) (Figure 8).

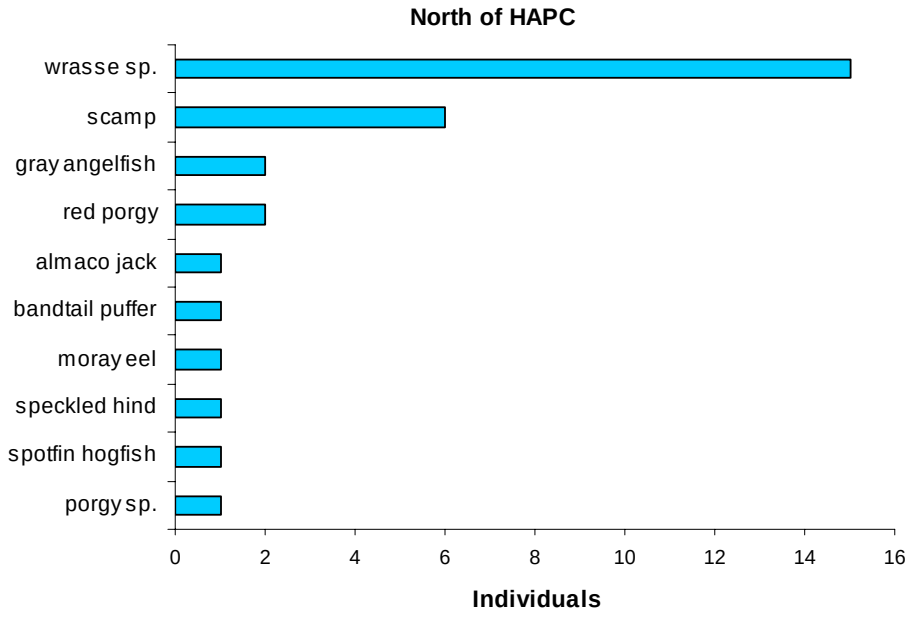


Figure 6. Maximum number of individuals by species observed to the north of the Pulley Ridge HAPC from the camera array.

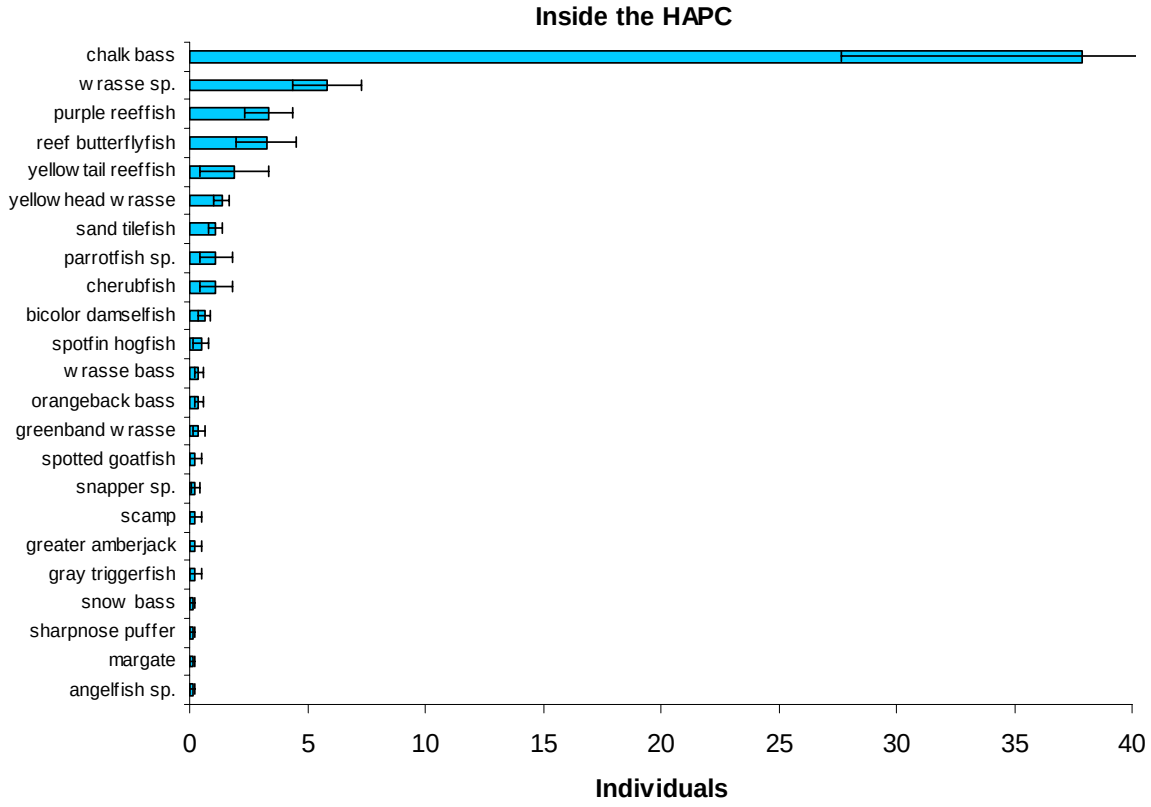


Figure 7. Average maximum number of individuals and S.E. by species observed inside the Pulley Ridge HAPC from the camera array.

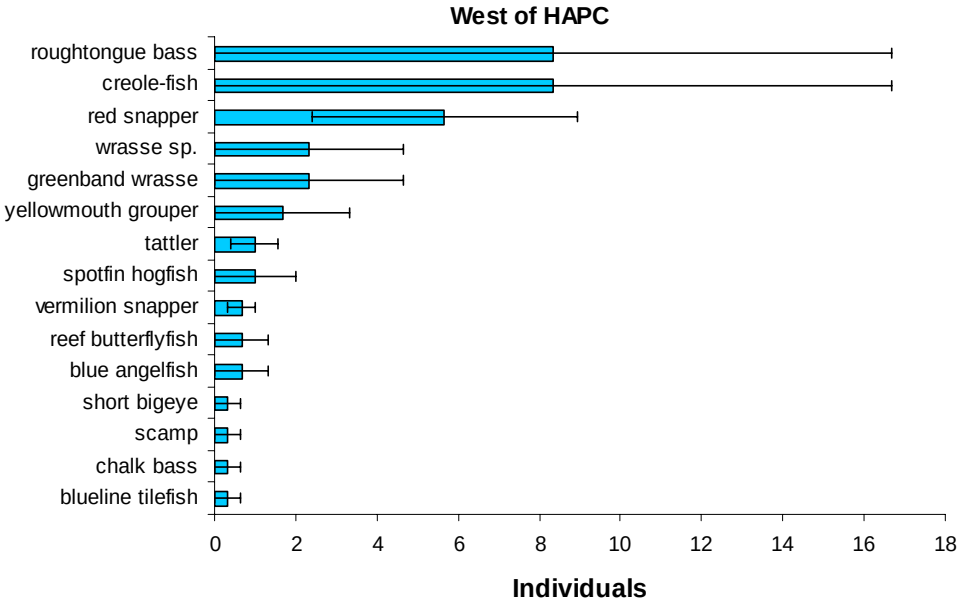


Figure 8. Average maximum number of individuals and S.E. by species observed to the west of the Pulley Ridge HAPC from the camera array.

In conclusion, we have completed two surveys on Pulley Ridge in the past 10 months and will continue to do bi-annual surveys of the area to monitor coral health and changes in fish assemblages. We observed distinct differences between northern and southern Pulley Ridge. Northern Pulley Ridge is comprised of more carbonate rock in the form of outcrops and pavement while southern Pulley Ridge is characterized by rock rubble with hermatypic corals and higher fish diversity. Sand tilefish mounds and red grouper pits were also observed in southern Pulley Ridge. Several observations of fishing gear (monofilament line, longline, and fish traps) were made during the ROV dives along the entire ridge, both inside and outside the HAPC.

## Acknowledgements

We would like to thank the crews of the NASA Ship M/V Freedom Star and the NOAA Ship Gordon Gunter as well as NOAA's Teacher-at-Sea program participants. We also thank NURC/UCONN and NURC/UNCW for providing ROV services, Dr. David Naar at the University of South Florida for producing the multibeam acoustic imagery, and John Reed of Harbor Branch Oceanographic Institute for historical information and invertebrate identifications. This project was supported in part by a grant from NOAA's Coral Reef Conservation Program.

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